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16. ABSTRACT

The US. Army Toxic and Hazardous Materials Agency and the U.S. EPA Water Engineering Research Laboratory cooperated to investigate the feasibility of Plastic Media Blasting (PMB) as a paint removal technique for aluminum military shelters. The PMB process was compared in field tests with sandblasting and with chemical stripping to determine relative cost, effectiveness, efficiency, and environmental consequence. The PMB process was judged superior to the chemical stripping process and marginally better than sandblasting based upon the evaluation criteria.

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TECHNICAL, ENVIRONMENTAL, AND ECONOMIC EVALUATION OF PLASTIC MEDIA BLASTING FOR PAINT STRIPPING. Charles H. Darvin, Air and Energy Engineering Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711 and Roger C. Wilmoth, Water Engineering Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH 45268

1. INTRODUCTION

Paint removal operations can be major generators of air, water, and solid waste pollution. There are two traditional methods used for industrial paint removal operations--sandblasting and chemical stripping. Over 60,000 tons per year of methylene chloride is used as a chemical stripping agent resulting in air, water, and solid waste pollution. In addition, countless tons of toxic metal contaminated sand from sandblast stripping must also be disposed of in an environmentally safe manner. Therefore, the unique method of plastic media blasting (PMB) for paint removal promises to significantly reduce air, water, and solid waste pollution from paint stripping operations.

In early 1985, the U.S. Army and the U.S. Environmental Protection Agency embarked upon a joint effort to identify major sources of multimedia pollution from selected Army maintenance operations. An objective was to recommend solutions to the identified pollution problems and evaluate their potential to reduce pollution discharges. The Army facility selected for the initial evaluation program was the Sacramento Army Depot, California. The two major hazardous pollutant sources identified were chemical stripping and sandblasting paint removal operations. Plastic media blasting for paint removal was recommended as a replacement for sandblasting and some chemical stripping operations. A joint research project was initiated with the U.S. Army Toxic and Hazardous Materials Agency to compare PMB with sandblasting and solvent chemical stripping. The sandblasting and the PMB operations were evaluated at the Sacramento Army Depot. The chemical stripping operation was evaluated at the McClellan Air Force Base, California, Air Logistics Center.

This paper presents the technical, economic, and environmental findings of the program that evaluates and compares the three paint removal processes. The paper addresses three areas: the quality of the finished product, the speed of removal, and the environmental impact of each process. More importantly, it shows that, when cost of pollution control is taken into account the total production cost can be signficantly reduced when using PMB.

Background

The use of organic chemicals or sandblasting are the most common methods for removing paint from metal or composite structures. Typical military specification chemical strippers contain up to 85 percent methylene chloride, a designated hazardous pollutant. Other organics which can be found in these strippers include methyl ethyl ketones (MEK) and phenols. These chemicals, when used in industrial stripping operations, result in both air and water

pollution. The increasing restrictions on the discharge of these chemicals and other contaminated wastes by the U.S. EPA and the State environmental agencies will make future discharge and disposal difficult and expensive.

Many institutions have been researching substitute methods for removing old or damaged paint. Methods under investigation include laser light, flash lamps, and high pressure CO_2 pellets--another form of blasting. The methods in most common usage, however, are chemical stripping and sandblasting. Both of these methods, however, have inherent problems. Sandblasting can be aggressive to softer metals and composites. Chemicals result in large volumes of contaminated rinse water and toxic sludges.

PMB is a unique variation of the sandblasting process which uses plastic beads rather than silica sand. Similar to sandblasting, the media impacts upon the surface and attacks the paint covering the substrate. However, due to the hardness of the plastic beads, approximately 3 to 5 Mohs, it is non-abrasive to the metal substrate, which typically has surface hardness greater than 6 Mohs. Sand has a Mohs hardness of approximately 7. The relatively low Mohs hardness of the plastic beads permits PMB to be used on surfaces and in areas which cannot be processed by sandblasting or chemicals and, therefore, has a significant advantage over other stripping techniques. A disadvantage, however, is that PMB will not remove rust, since the beads are softer than rust.

Objective

The objective of this study was to show that PMB is significantly cheaper in total manufacturing costs when compared to other paint stripping processes. When the real costs associated with pollution control are taken into account, the resulting costs can be significantly greater than when defining process costs by only material, equipment, and labor costs. PMB has the advantage of lower pollution, thus lower resulting environmental control cost impact. This study evaluated those costs.

Approach

The subjects of the evaluations were military shelters of the type used to house communication electronics. The PMB evaluation program was designed to compare stripping processes in three areas: the quality of the surface finish, the speed of paint removal, and the environmental impact of the process and the ultimate processing cost when taking environmental control into account. The quality requirements of the surface finish were defined by military specifications, with surface quality evaluations completed by facility technicians. The stripping speed and environmental impact evaluations were completed by using elapsed time and analytical results, respectively. The time determinations were nozzle-on elapsed times for PMB and sandblasting evaluations, and application, setting, and rinsing elapsed times for chemical stripping. The recorded elapsed times did not include unit preparation times

for sandblasting and chemical stripping, although they would have further increased unit processing times for the two processes. Also, due to the aggressive nature of sandblasting and chemicals, hand sanding is normally required to process the interior of the electronic shelters during these stripping operations. PMB can be used on the interior surfaces without causing damage. Hence, hand sanding was accounted for during the sandblasting and chemical stripping evaluations.

A total of 14 shelters of similar size and configuration were evaluated. They included three evaluated for chemical stripping, six for sandblasting, and five for PMB. Figure 1 shows a typical electronic shelter of the type used during the evaluation. The quantitative data collected during each evaluation run included total shelter surface area, stripping time, paint type, material used, and volume of waste generated.

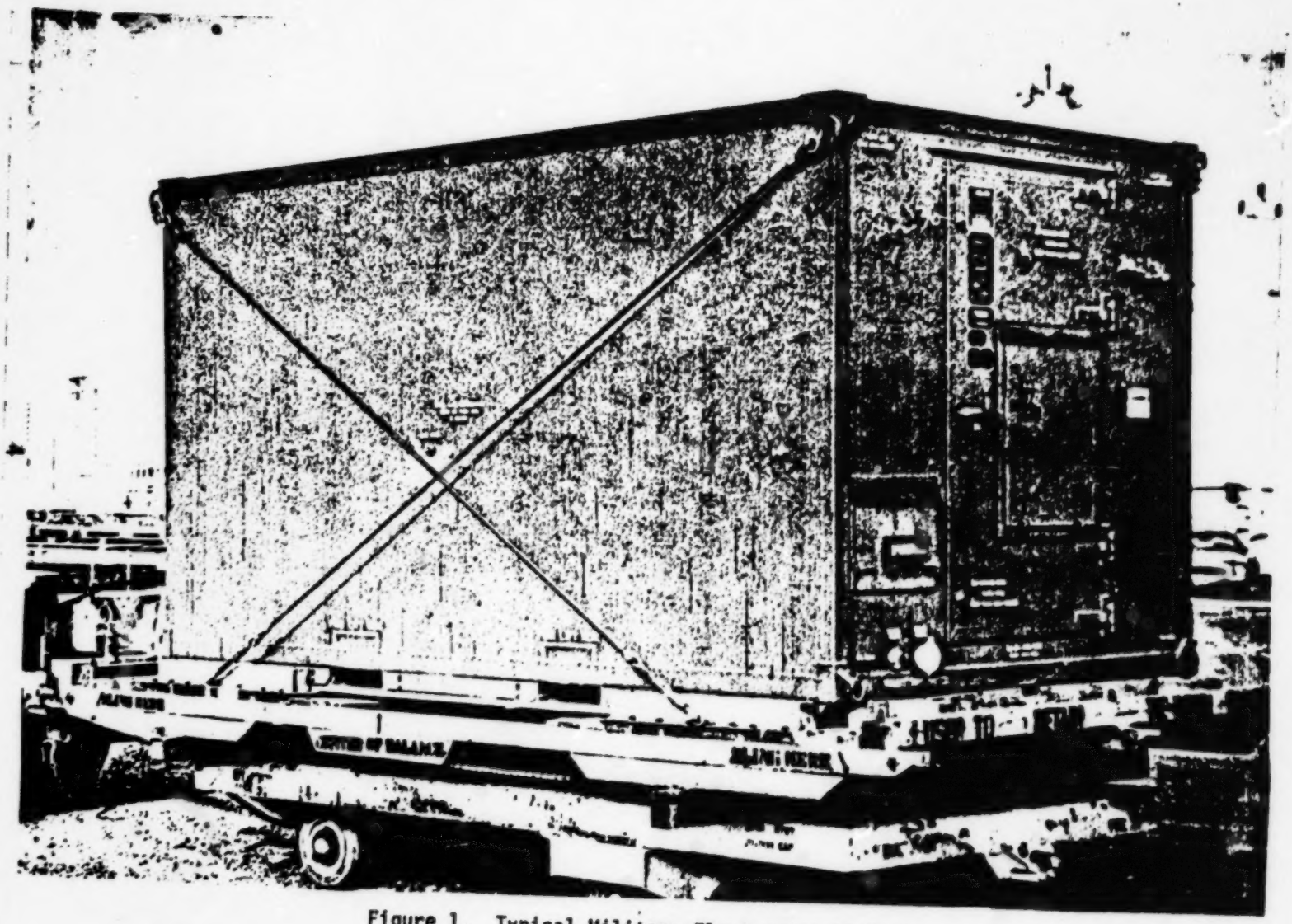

Figure 1. Typical Military Electronics Shelter

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2. PROCEDURE

Sandblasting

Sandblasting evaluations were conducted at the Sacramento Army Depot, California. A total of six shelter stripping operations were observed. Due to the abrasive effect of sand on the aluminum surface of the shelters and potential contamination of electronics by sand, only the outside of the shelters was sandblasted. All sandblasting was conducted in dedicated enclosure. The inside of the shelters was sanded by hand. As shown in Table 1, the paint removal rates for sandblasting on the outside of each shelter ranged between 2.86 and 10.49 ft^2/min.* However, the inside removal rate averaged only 0.74 ft^2/min. Thus, the actual cleaning rate for sandblasted shelters for both inside and outside ranged between 1.8 and 5.6 ft^2/min. It should also be noted that inside stripping was incomplete and of minimal quality. As expected, multilayered coatings required the greatest effort. As shown for units 3 and 5 in Table 1, which were coated with multilayered camouflage paints, the paint removal effort was two to three times slower than for single coatings.

Chemical Stripping

Chemical stripping evaluations were conducted at the McClellan Air Force Base, California, Air Logistics Center. One small and two medium size shelters were observed. Data similar to those taken during the sandblasting evaluations were collected. However, the total outside processing time included the sum of the chemical application, reaction, and rinse-down elapsed times. The stripper was primarily methylene chloride in a wax base to allow adherence to the unit surface. For certain difficult removal situations a supplementary phenolic stripper was used. Table 2 summarizes the results of the chemical stripping evaluations.

Chemical stripping was also determined to be a time-consuming process with equally large volumes of liquid waste. Due to the corrosive nature of the stripping chemical, only the outside was chemically stripped. The inside of each unit was sanded by hand which, when combined with the outside stripping time, was less than the sandblasting rate. The waste generated as shown in Table 2 was approximately equivalent to that generated during sandblasting ranging between 1.7 and 3.3 gal. of liquid waste per ft^2 of surface area. The waste volumes were determined by the thickness of the coating and its resistance to the chemical stripper. As shown for unit 3 in Table 2, the stripping rate was significantly less than for the larger units. Due to the additional stripper applications, the waste generation rate was significantly greater. Approximately 25 percent of the liquid waste generated required handling and disposal as a hazardous waste sludge.

*Readers more familiar with metric units may use the conversion table at the end of this paper.

TABLE 1. SUMMARY OF SANDBLAST STRIPPING

Unit No.	Area Stripped (ft^2)		Stripping Time (min)		Rate (ft^2/min)		Estimated Stripping Rate (ft^2/min)	Sand Used (lb)	Material Waste Rate (lb/ft^2)
	Outside	Inside	Outside	Inside	Outside	Inside			
1	189	71[a]	24.4	93[a]	7.74	0.76[a]	4.25	325.6	1.7
2	189	36[a]	25.0	50[a]	7.56	0.72[a]	4.14	333.3	1.8
3	189[c]	--	66	--	2.86	0.74[b]	1.8	880.0	4.7
4	249	--	33	--	7.54	0.74[b]	4.14	440.0	1.8
5	249[c]	--	67.3	--	3.70	0.74[b]	2.20	897.3	3.6
6	249	--	23.8	--	10.49	0.74[b]	5.60	317.6	1.3

[a]Real time data [b]Estimated sand rate [c]Multilayered

TABLE 2. SUMMARY OF CHEMICAL STRIPPING

Unit No.	Area Stripped (ft^2)		Stripping Time (min)		Rate (ft^2/min)		Total Average (ft^2/min)	Chemical (lb)	Used (gal.)	Chemical Use Rate (lb/ft^2)	Waste Rate (gal./ft^2)
	Outside	Inside	Outside	Inside	Outside	Inside		Stripper[a]	Water		
1	342	N/A	692	N/A	0.50	0.74[b]	0.62	194	1572	0.57	1.9
2	387	N/A	1345	N/A	0.30	0.74[b]	0.51	370	2636	0.96	1.7
3	180[c]	N/A	1126	N/A	0.17	0.74[b]	0.46	149	2336	0.83	3.3

[a]Includes all organics [b]Estimated from sandblast results [c]Supplementary phenolic stripper used

Plastic Media Blasting

Five shelters were processed at the Sacramento Army Depot using PMB. The units were of similar size and configuration of those evaluated for chemical stripping and sandblasting. However, unlike the chemical stripping and sandblasting operations, both the outside and inside of each shelter was stripped using PMB, thus eliminating the time-consuming hand sanding. The times determined for stripping those units, therefore, included both the inside and outside. In addition, since PMB had no effect on seals, gaskets, or surface preparation, masking was not required.

The plastic media was blasted at approximately 30 psi, which is lower than for sandblasting. Over the total evaluation program, a total of 450 lb of paint dust and media were discarded as waste. This represented 18 percent of the media charge. Table 3 summarizes the results of the PMB evaluation. Since hand sanding was not required, the inside cleaning rate was typically no greater than twice the outside cleaning rate. This difference can be attributed primarily to the limitations of the evaluation site. Unlike a dedicated PMB installation with bead retrieval apparatus and filters, the inside of each shelter was stripped without the aid of bead retrieval or ventilation to remove dust. Thus, periodic shutdowns were required during the evaluation to permit bead retrieval and dust settling. The stripping rate for shelter A (Table 3) was significantly less than those recorded for the remaining shelters in the series. A silica impregnated floor coating was used which required significantly greater effort to strip. The stripping rate for the remaining shelters reflected the relative paint thicknesses between the single coatings and the multilayered camouflage coatings.

TABLE 3. SUMMARY OF PMB PAINT REMOVAL

Shelter	Area (ft^2)			Stripping Time (min)			Stripping Rate (ft^2/min)		Average Stripping Rate (ft^2/min)	Plastic Media Usage Rate[a] (lb/ft^2)	Waste Material (lb)	Material Waste Rate (lb/ft^2)
	In	Out	Total	In	Out	Total	In	Out				
A[b]	394	335	729	588	201	789	0.67	1.67	0.92	<0.18	<131	<0.18
B	178	168	346	82	139	221	2.17	1.21	1.57	<0.18	<62	<0.18
C	178	168	346	102	69	171	1.75	2.43	2.02	<0.18	<62	<0.18
D[b]	394	335	729	136	123	259	2.90	2.72	2.80	<0.18	<131	<0.18
E[b]	178	168	346	47	113	160	3.79	1.49	3.06	<0.18	<62	<0.18

[a]Estimated from total waste product generated over the evaluation program
[b]Multilayered camouflage enamel paint

3. RESULTS AND DISCUSSION

The viability for industrial application of any paint stripping process is defined by its costs and the quality of the surface finish after stripping. Thus, the objective of this program was to determine the technical and economic factors that define the limits of the PMB technique and compare them to those for sandblasting and chemical stripping. The results relied both upon the subjective judgements of quality control experts and on realtime data collected during stripping operations at two military maintenance facilities.

The surface quality after paint stripping was determined by quality control inspection based upon military specification surface requirements. The three techniques produced acceptable repainting surfaces, although of varying degrees of quality. The inside surfaces of the sandblasted and chemically stripped units were of minimum overall quality since hand sanding permits only partial removal of paint. The PMB units were determined to have the best overall surface quality. For PMB the surface quality of the inside was considered equivalent to the outside surfaces. The stripping rate of PMB on simple flat metal (T2024 aluminum) surfaces was determined to be less than that for sandblasting, but greater than for chemical stripping. However, due to the complex surfaces inside the shelters, PMB was significantly faster (by a factor of three) on the interior surfaces when compared to hand sanding. Thus, based on the average stripping rate for each process, PMB was at least 30 percent faster than sandblasting and 65 percent faster than chemical stripping, since both the latter processes require hand sanding of the interior surfaces.

Because sandblasting waste is not presently disposed of as a hazardous waste at the test site, PMB was determined to be marginally more expensive than sandblasting, but significantly less expensive than chemical stripping. As shown in Table 4, and based on an 82 percent recycle rate for PMB, the process cost for sandblasting was determined to be approximately \$0.35 per ft^2, with PMB and chemical stripping \$0.47 and \$2.58 per ft^2, respectively. By breaking down the respective cost element as in Table 4, it can be seen that the significant cost element for sandblasting, however, was labor at \$0.25 per ft^2. The materials costs were \$0.09 per ft^2 for high-grade sand, and subsequent waste disposal was less than \$0.01 per ft^2 stripped. The disposal rate for PMB was determined to be marginally higher than sandblasting due only to the designation of the subject sandblast waste as non-hazardous. A change in the designation of sandblast waste would result in a waste disposal cost for sandblast in excess of \$0.13 per ft^2 and thus increase the total process cost for sandblasting to \$0.50/ft^2. Due to the efficiency of PMB in processing the inside of the shelters, thus eliminating time-consuming hand sanding, the actual labor rate for PMB was significantly lower than for the other processes.

TABLE 4. COMPARISON OF PAINT STRIPPING METHODS FROM DATA COLLECTED DURING EVALUATION

Paint Stripping Method	Average Stripping Rate (ft^2/min)		Material Use Rate (lb/ft^2)	Waste Generation Rate (lb/ft^2)	Estimated Labor Rate[a] ($/$ft^2$)	Material Cost Rate ($/$ft^2$)	Waste Disposal Rate ($/$ft^2$)	Total Process Cost[b] ($/$ft^2$)	Projected Process Cost[c] ($/$ft^2$)
	Outside	Inside							
Sandblasting	6.64	0.74	2.4	2.4	0.25	<0.09	<0.01[d]	0.35	0.50
Chemical	0.32	0.74	0.8	2.3	0.65	1.80	0.13[e]	2.58	2.58
Plastic Media Blasting	2.26	1.9	<0.18	<0.18	0.10	0.36	0.01	0.47	0.31

[a]Labor rate estimated at $10.00 per hour

[b]Based on collected data

[c]Based on added assumptions: (1) Sandblast waste treated as hazardous waste
(2) 90 percent bead recycle rate

[d]Disposed of at nonhazardous rate

[e]Approximately 25 percent of total liquid waste disposed of as hazardous waste

Finally, the plastic media recycle rate as determined during this program was 82 percent. This was due primarily to the limitation of the experiment. Since the beads can be efficiently classified and recycled at greater than 90 percent, it is therefore possible and probable that most operations would operate at a 90 to 95 percent recycle rate. Thus, the major cost item for PMB material cost at \$0.36 per ft^2, could be significantly lowered. At a 90 percent recycle rate, the material rate for PMB would be reduced by 55 percent to approximately \$0.20 lb/ft^2 and thus become more economical than sandblasting or chemical stripping. The last column of Table 4 compares the process costs based on a 90 percent plastic media recycle rate.

Conclusions

The results of the evaluation program data for PMB indicate that PMB is only marginally more expensive than sandblast paint stripping. However, with only a minor increase in plastic media recycle rates, PMB will be less expensive to operate than sandblasting and has the benefit of lower disposal volumes.

The quality of the surface finish using PMB is superior to that using chemicals or sandblasting. PMB does not require masking, or result in surface etching or seal destruction. This permits significant time and long-term cost savings over other techniques.

PMB is slower than sandblasting, yet faster than chemical stripping on flat simple surfaces. PMB is faster and more efficient on complex surfaces where hand sanding must be used. PMB can be considered a technically and economically viable alternative paint stripping process for many paint removal requirements. Although this study was conducted at a military maintenance installation, the conclusions derived should be consistent in the private industrial sector.

TABLE 5. METRIC CONVERSION TABLE

Nonmetric	Times	Yields Metric
ft^2	0.09	m^2
gal.	3.79	L
lb	0.454	kg
psi	6.89	kPa
ton	907.18	kg